

CAPE COD AIR STATION
Massachusetts Military Reservation
Sandwich vicinity
Barnstable County
Massachusetts

HAER No. MA-151

HAER
MASS,
1-SAND.V,
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, Pennsylvania 19106

HISTORIC AMERICAN ENGINEERING RECORD

CAPE COD AIR STATION

HAER No. MA-151

Location: Massachusetts Military Reservation, Sandwich vicinity,
Barnstable County, Massachusetts

UTM: 19-372090-4623280
Quad: Sagamore, Massachusetts, 1:24,000

Date of Construction: 1978 (operational 1979)

Engineer: Raytheon Equipment Division, Wayland, MA under direction of the
Rome Air Development Center, Griffiss AFB, NY. (Construction
subcontractor: Gilbane Construction Company, Providence, RI)

Architect: Raytheon Equipment Division, Wayland, Massachusetts

Present Owner: U.S. Air Force, 21st Space Wing, Air Force Space Command

Present Use: Radar facility (ballistic missile tracking)

Significance: This facility is one of four PAVE (Air Force program name) Phased
Array Warning System (PAVE PAWS) sites located in the U.S. It was
designed to provide early warning and tracking for submarine-launched
ballistic missiles (SLBMs). It was the first ground-based SLBM
detection and tracking unit to be deployed by the U.S. It was designed to
provide sufficient warning time to sustain a credible second strike
deterrent and counter the Soviet threat of forward deployment of
ballistic missiles patrolling the coasts of North America.

Project Information: Post-Cold War downsizing has resulted in a number of necessary
changes to Cold War era facilities. Two of the PAVE PAWS sites
(Texas and Georgia) are no longer operational and have been partially
dismantled. Several engineering projects required at the Cape Cod site
have been determined to have adverse effects on the historic integrity of
the radar facility. The Air Force, State Historic Preservation Officer,
and the Advisory Council on historic preservation entered into a
Programmatic Agreement, which calls for documentation of the Cape
Cod site prior to any adverse action. This package fulfills the stipulation
for HABS/HAER documentation noted in that agreement.

Prepared by: Mandy Whorton, Environmental Scientist, Argonne National
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17 April 2000

Summary Description of Cape Cod Air Station and Its Setting

Cape Cod AS is located across the Sagamore Bridge off the coast of Cape Cod Bay, about 60 mi southeast of Boston. Cape Cod AS comprises 100 acres of leased land in the northeastern boundary of the state-owned Massachusetts Military Reservation (MMR), a 20,000-acre parcel of land that houses a variety of military units, including units of the Air National Guard, Army National Guard, U.S. Coast Guard, and Cape Cod AS. The area is generally forested and relatively flat. The technical facility is located on the second highest point on Cape Cod at 255 ft above sea level.

Cape Cod Air Station was constructed in 1978 as the first of four sites in the U.S. for the PAVE (Air Force program name) PAWS (Phased Array Warning System)¹ for the early detection of submarine-launched ballistic missiles (SLBMs) and intercontinental ballistic missiles (ICBMs). The Cape Cod complex consists of ten buildings, including a joined technical facility and power plant (HAER No. MA-151-A) as well as ancillary structures, including a guardhouse, storage warehouse, satellite communications building (vacant), office building, and utilities and fuel storage structures. Most of the structures are within the restricted area, which is surrounded by a security fence. Armed security forces monitor all activity around the site; they are assisted by numerous cameras and motion detectors located along the security fence. Security personnel are on duty 24-hours a day and constitute approximately one-quarter of all installation personnel. All buildings are steel-framed and clad with light beige metal paneling. The buildings within the restricted area are constructed on an elevated concrete pad, which also has been cleared of all landscaping and plant material.

The main mission activity at the installation centers around the Technical Facility/Scanner Building (HAER No. MA-151-A), which houses the AN/FPS-115² radar and related equipment that detects and tracks SLBMs and ICBMs aimed at the continental U.S., Alaska, and northern Canada. Cape Cod AS PAVE PAWS Site 1 provides coverage for a 3,000-mi area from the Atlantic, Caribbean, and northwest Arctic Ocean regions and has the power and sensitivity to detect an object as small as 10 m² at this distance. Once a ballistic missile has been detected, the system can track the missile or any of its components as small as 1 m². Data generated by the system are transmitted to Air Force control centers and the Pentagon. In addition to ballistic missile detection and tracking, PAVE PAWS Site 1 also participates with other radar sites in detecting, tracking, and identifying space objects.

¹ Early reports translate the PAVE acronym as Precision Acquisition Vehicle Entry. It is also referenced in some documents as Perimeter Acquisition Vehicle Entry. Recent Air Force materials on the system, however, distance themselves from these designations and characterize it instead as an inconsequential program name.

² The PAVE PAWS expansion with facilities in Georgia and Texas used upgraded radar, the AN/FPS-123. PAVE PAWS radar at the first two sites, including Cape Cod, is sometimes referred to with this designation.

Historical Significance of Cape Cod Air Station

Cape Cod Air Station is the site of the first U.S. SLBM early warning phased array radar. Its radar facility and power plant meet the criteria for inclusion in the National Register of Historic Places based on their association with important events in the Cold War (1946-1989) between the U.S. and U.S.S.R. The design and deployment of the dual-faced phased array radar also meets the NRHP criteria for significant engineering design.

Historical Development of PAVE PAWS

The U.S. developed PAVE PAWS to guard the ocean flanks of North America from the threat of SLBMs. The original deployment of PAVE PAWS units covered the Atlantic and Pacific oceans, but facilities were later constructed to cover the Caribbean as well.

The widespread deployment of SLBMs represented an important shift away from the "polar concept" that had dominated strategic defense during the first half of the Cold War (Schaffel 1991). The polar concept reflected the fact that Soviet long-range bombers and ICBMs were confined to bases on the territory of the U.S.S.R. and limited to attack routes across the polar region. Khrushchev's attempt to circumvent these limits to Soviet strategic offensive capability (which was especially weak in 1962) by deploying intermediate range ballistic missiles (IRBMs) and bombers at forward bases in the Caribbean provoked the Cuban Missile Crisis. By the early 1970s, however, the Soviet Union had achieved effective forward deployment around the North American continent on submarines. Despite limitations on command and control (given the constraints of communication with vessels submerged in deep water), the presence of nuclear submarines contributed significantly to the superpower balance of the 1970s. Even assuming high failure rates, the submarine forces deployed by both sides by the 1970s could have destroyed most or all of the major urban centers of either country, which represented an unacceptable loss (Daniel 1986).

The U.S.S.R. had successfully launched an SLBM (the SS-N-4 Sark) as early as 1955, but it had been fired from a diesel-powered submarine on the surface and had a range of only 350 miles. While the U.S.S.R. continued to make technological advances in their submarines and SLBMs in the 1950s and 1960s, a number of factors — including crude engineering, a shortage of maintenance crews, limited submarine and missile ranges, and changes in Soviet military thinking — limited the strategic offensive potential of these early submarines and ballistic missiles (Zaloga 1993; Catudal 1988). It was not until the late 1960s that the U.S.S.R. commissioned its first modern nuclear submarine (code-named "Yankee"). By 1969, two Yankee Class submarines, each carrying 16 SLBMs (SS-N-6) with ranges of up to 1,300 mi, were patrolling the east coast of the U.S. (Moore and Compton-Hall 1986).

The U.S. responded to the new, although limited, threat of the U.S.S.R. SLBM fleet with the construction of conventional radar detection and tracking system. The system consisted of

seven AN/FSS-7 radar sensors located along the coastal perimeters of the U.S. The radars were deployed on the east coast at MacDill AFB (Florida), Fort Fisher Air Force Station (AFS) (North Carolina), and Charlestown AFS (Maine); on the west coast at Mount Hebo AFS (Oregon), Mill Valley AFS (California), and Mount Laguna AFS (California); and on the Gulf Coast at Laredo AFS (Texas). All sites became operational in 1971 (Pretty 1979).

Throughout the 1970s, the U.S.S.R. continued to improve the designs of and deploy in greater numbers SLBM-equipped nuclear submarines. By 1974, 34 Yankee Class submarines were operating off both coasts of the U.S., and in 1973, the first "Delta" Class submarines were deployed. This class of submarine was equipped with the world's first long-range (4,300 mi) SLBM, the SS-N-8.³ The extended range of the Delta submarines meant that they could strike targets from nearby coastal waters, and, in some cases, from their homeports. During 1971-1980, the U.S.S.R. systematically deployed nuclear submarines off the U.S. coasts in an effort to reach parity with U.S. capabilities (Watson 1982:29-35). Although these deployments were aggressive, unlike the Cuban missile crisis of 1962, they were executed conservatively. By the end of the 1970s, the Soviets had developed a competent ballistic-missile equipped submarine force that provided a balance to U.S. capabilities in this area (Watson 1982:173-4).

As the U.S.S.R. developed and deployed a more advanced SLBM-equipped submarine fleet, the conventional AN/FSS-7 radars became obsolete. Each of these radars, which were designed by Avco Electronics Division, had a parabolic antenna that performed, in conjunction with automated computer controls, both search and tracking functions. The radars had limited ranges (800 mi), moved mechanically, and could only track single objects.

To guard against the more advanced Soviet submarine fleet, the U.S. constructed a new phased array missile early warning system. Planning for the new system, called PAVE PAWS, began in 1973; it was commissioned in 1976. The first two PAVE PAWS sites were completed at Otis AFB in Massachusetts (renamed Cape Cod AS) and Beale AFB in California by 1978 and became operational in 1979 and 1980, respectively. The AN/FSS-7 radars were dismantled when these PAVE PAWS units became operational.

Development and Use of Phased Array Radar

Phased array radars aim electronically rather than mechanically. The radars have flat faces covered by thousands of individual antenna elements incorporated into the exterior wall(s) of a large building. Each antenna emits a tiny portion of the radar beam. The array of receiving

³ The U.S. enjoyed significant naval superiority throughout the Cold War, but one milestone that the Soviets did meet first was the development of the ultra-long-range SLBM. The SS-N-8 first appeared eight years before the MIRVed Trident C-4. The reason that the Soviets were to the first to develop this capability was probably a combination of a need to compensate for the fact that their submarines could not be deployed for long periods of time because of maintenance problems coupled with geographic limitations that did not provide much strategic flexibility in planning a route to the U.S.

elements is fixed, but the beam can scan and adapt its position nearly instantaneously by adjusting the current through the array of antenna elements. As a result, phased array radars can detect and track a greater number of objects simultaneously and with far greater precision than conventional radars (Brookner 1985; Billetter 1989).

Radar systems specifically designed for detecting and tracking missiles and orbiting satellites are very large and require immense electrical power to operate. Such radars might be required to have maximum ranges of 2,400 to 3,600 miles, compared with a typical range of 240 miles for a long-range aircraft detection system. Because of the need for an extended range, missile tracking systems operate with a power level about 100 times greater than the power required for aircraft detection. Antennas for missile detection are also very large and can be up to 100-m wide.

Development of this technology began in the mid-1960s and had been used in a limited way for missile tracking before the deployment of PAVE PAWS. Large, ground-based phased array radar was first deployed at Eglin AFB in 1967 for use in tracking space objects. This facility was expanded in 1974 with a secondary mission to detect and track SLBMs, replacing the coverage of the Texas AN/FSS-7 site (Klass 1973). The AN/FPS-85 radar at Eglin had separate array faces for transmitting and receiving. Also in 1974, two phased array facilities became operational at the Safeguard ABM Complex in North Dakota for ICBM warning; these radars were north-pointing. (A full-size test facility for the Safeguard radar also was constructed on Kwajalein Atoll in the Marshall Islands in 1974.) Two years later, the Cobra Dane phased array radar was deployed at Shemya Island in the Aleutians to monitor Soviet missile tests near the Kamchatka peninsula. Cobra Dane also had a secondary mission of tracking space objects and providing early warning of missile attacks in the northern Pacific. The first two PAVE PAWS sites in Massachusetts and California represented the first two-faced phased array radars deployed by the U.S. In the late 1980s, two of the three Ballistic Missile Early Warning System (BMEWS) sites were upgraded to phased array using the PAVE PAWS design. BMEWS was the first ballistic missile detection and tracking system deployed by the U.S. Operational in the late 1950s, BMEWS relied on mechanical radar technology. The third BMEWS site is scheduled for upgrade to phased array radar in 2002.

The phased array radar structures employ a number of common characteristics, including size, geometric shape, construction materials, circular array placement, and consolidated functions. All of the structures are very large to accommodate the large size of the radar face(s) – the largest at Eglin measures 350 ft by 155 ft for its receiving component and 350 ft by 95 ft for its transmitting component. The PAVE PAWS faces are all square, measuring approximately 100 ft by 100 ft. With the exception of Eglin, the facilities are trapezoidal in shape with one to three faces offering 120 to 360 degrees of coverage. The early facilities were constructed of reinforced concrete to provide protection against a nuclear blast. Later models, including PAVE PAWS, are steel structures with insulated aluminum panels on reinforced concrete pad foundations. The modification of the design was initiated for cost savings and reduced

construction time. The array pattern for the large phased array radars is circular. At the center (boresight) of the radar face, the elements are dense, becoming less dense closer to the circumference of the face. Not all of the antenna elements are active (i.e., not connected to wave tubes or power) but could be hooked up should additional capabilities be required. Thus, the radar facilities were designed with upgrades in mind. Finally, the buildings are self-contained with radar, processing, and analysis, and amenity (e.g., dining and leisure) functions under one roof.

Sources of Information/Bibliography

Engineering drawings

134 Architectural, Structural, and Mechanical Construction drawings, dated August 6, 1976 by Raytheon Company, are the property of the United States Air Force, 21st Space Command, Cape Cod Air Station.

21 Architectural Site Baseline Documentation drawings, dated 25 June 1993 by the US Air Force Space Command, are the property of the United States Air Force, 21st Space Command, Cape Cod Air Station.

Historic Views

Nine (9) historical photographs, ca. 1974 (the photographer unknown) are the property of the United States Air Force, 21st Space Command, Cape Cod Air Station.

Interviews: Ms. Nancy Fisher, Raytheon Support Services Company, Environmental Coordinator, PAVE PAWS Site 1, Cape Cod Air Station, June 1996; Mr. John P. Diehl, Raytheon Support Services Company, Civil Engineering Manager, PAVE PAWS Site 1, Cape Cod Air Station, June 1996; Mr. Les Easton, Raytheon Support Services Company, PAVE PAWS Site 2 Civil Engineering Manager, Beale AFB, November 1996; Dr. Coy Cross II, 9 RW/HO Historian, Beale AFB, November 1996; Mr. Bill Head, Robins AFB Historian, November 1996; Mr. Ray Hartsell, Raytheon Support Services Company, PAVE PAWS Site Manager, Site 3, Robins AFB, November 1996; Mr. Jim Newton, Raytheon Support Services Company, PAVE PAWS Civil Engineering Manager, PAVE PAWS Site 3, Robins AFB, November 1996; Dr. Richard Sturdevant, AFSPC Historian, Peterson AFB, Colorado, September 1995, January 1996, and March 1996; and Dr. Richard Ekert, AFSPC Historian, Peterson AFB, Colorado, September 1995 and March 1996.

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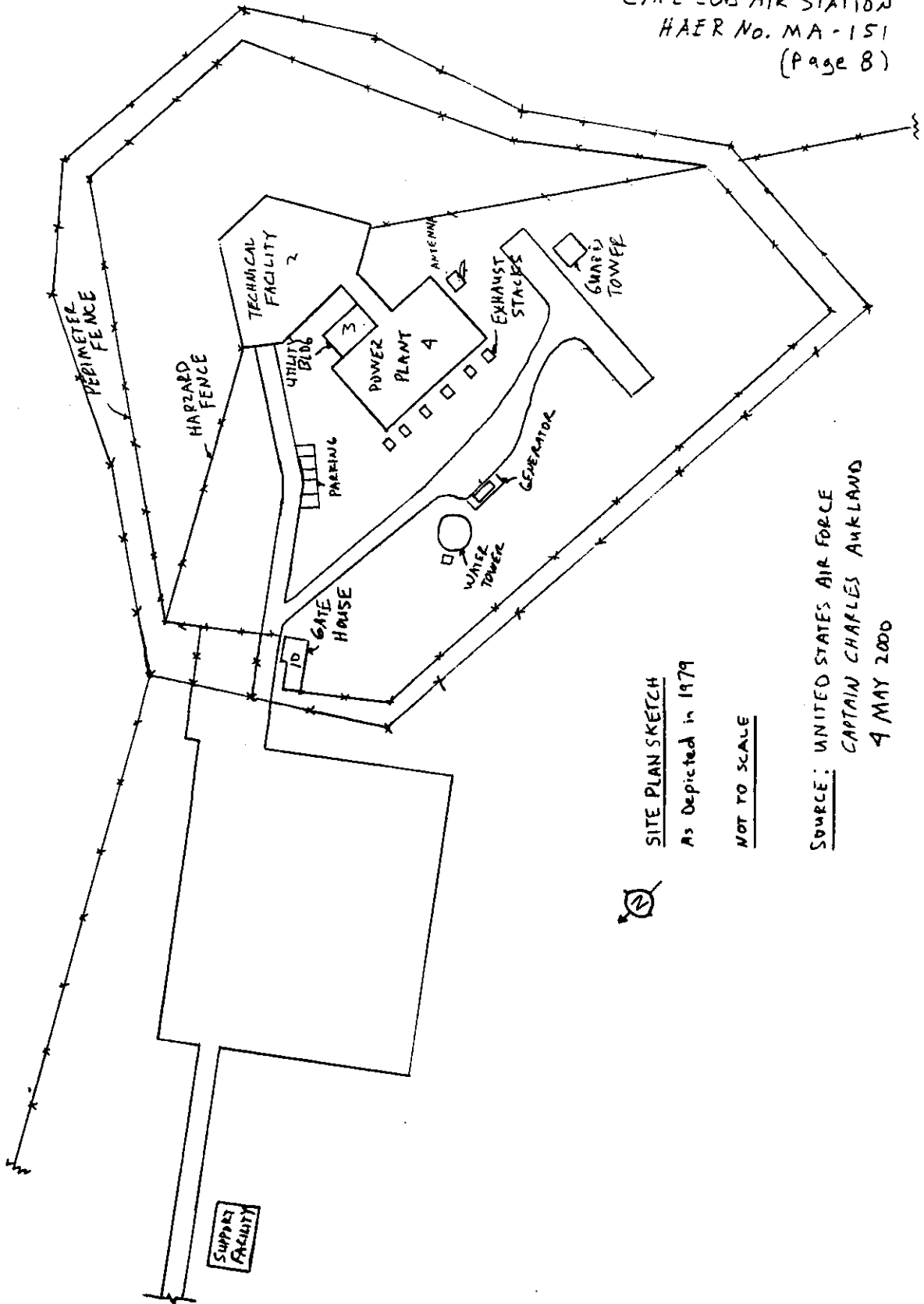
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Likely sources not yet investigated: Many materials of interest to the PAVE PAWS program and Cape Cod Air Station operations remain classified and were not included in this history. Classified documents available at the Air Force Historical Research Agency, Maxwell AFB, Montgomery, Alabama may contain useful information on the system and historical operations at Cape Cod Air Station. Consideration should be given to a classified review or to future review as documents become declassified. Additional interviews could be conducted with early PAVE PAWS Program Managers, including Mr. Richard L. Moore, as well as military commanders that served at the site during its period of significance.

Supplemental material: None.

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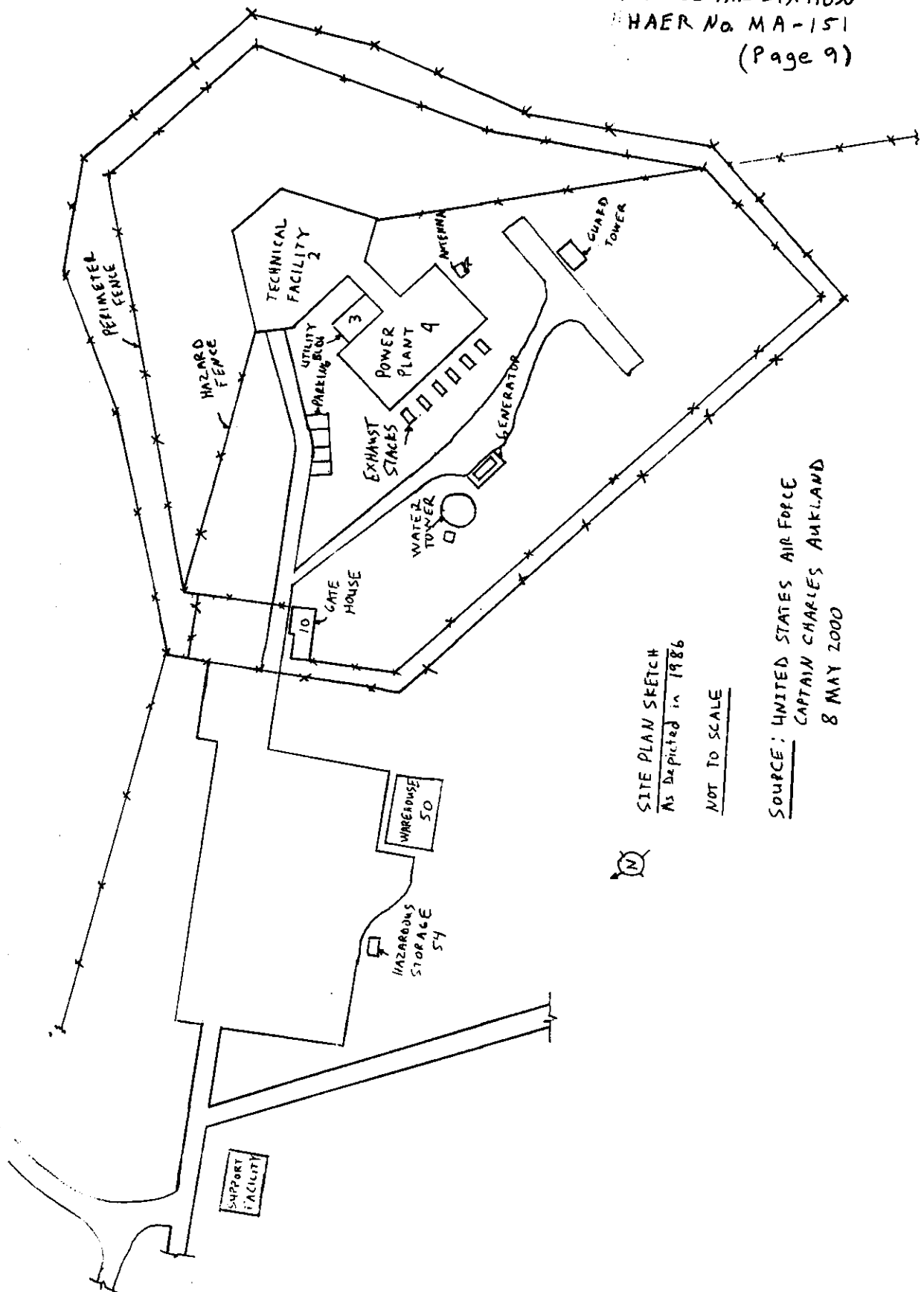


SITE PLAN SKETCH
As Depicted in 1979

NOT TO SCALE

SOURCE: UNITED STATES AIR FORCE
CAPTAIN CHARLES ANGLAND
4 MAY 2000

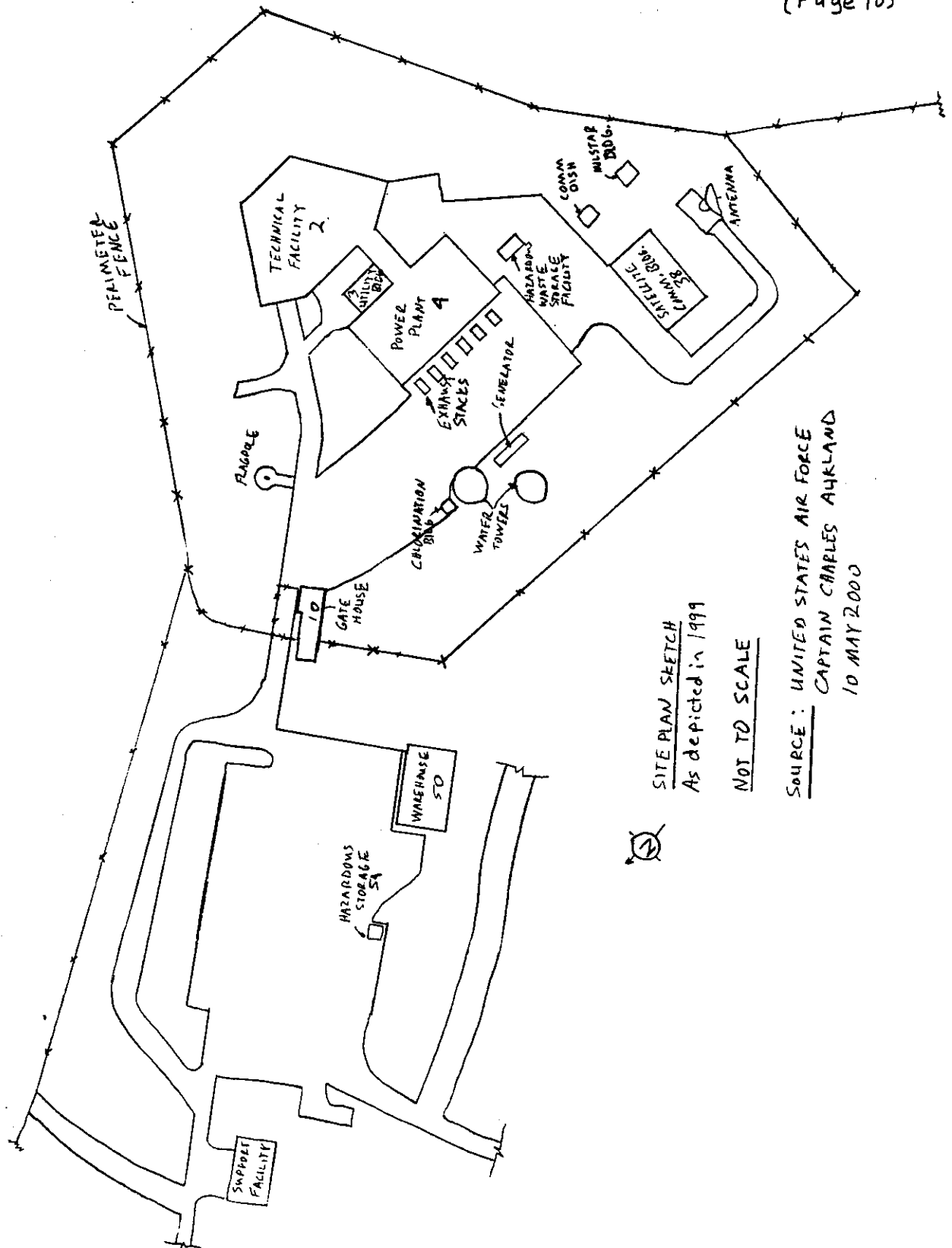
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SITE PLAN SKETCH
As Depicted in 1986

NOT TO SCALE

SOURCE: UNITED STATES AIR FORCE
CAPTAIN CHARLES AUKLAND
8 MAY 2000



SITE PLAN SKETCH
As depicted in 1999

NOT TO SCALE

SOURCE: UNITED STATES AIR FORCE
CAPTAIN CHARLES AYKLAND
10 MAY 2000